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Numerical Simulation of starting, particle-laden jets from pressurised containments

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Numerical Simulation of starting, particle-laden jets from pressurised containments

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Abstract

Volcanic eruptions frequently feature particle-laden, underexpanded, supersonic jets. The three adjectives signifying, well, firstly that there are particles in the jet, secondly that the pressure in the vent exceeds the atmospheric pressure by a factor of at least two (say) and that the vent is more or less straight, not resembling a classical Laval nozzle and thus leading to chocked conditions (i.e. reaching speed of sound) at the vent exit which further expands and thereby accelerates into the ambient. In case of an inward contraction, for example by some internal obstructions, the vent could form a kind of Laval–nozzle. In this case an overexpanded jet would develop.

The general features of this kind of flow without particles are well known from classical gasdynamics and the application to volcanic events was contributed e.g. by S. Kieffer [1]. Several numerical computations with varying degree of modelling assumptions are known from the literature.

Here we present such computations with a very accurate numerical description of - alas! - rather idealised volcanic jet events. A short outline of the numerical method will be given and put in perspective with respect to the computations of other groups.

The release of pressurised gas from finite and infinite containments is computed in three space dimensions with individually tracked Lagrangian particles. If time is measured in characteristic time units given by vent diameter (D) and speed of sound at the vent exit (c), we present results for varying durations, ranging from $t \ll D/c$ to $t \gg D/c$. The jet is feed by particles at the vent exit, meaning that for now the fluid particle interaction within the containment is not modelled. We compare the particle laden and empty jet and remark on the frequently used "pseudo–gas assumption".

References

[1] S. W. Kieffer, *Factors governing the Structure of Volcanic Jets, in Explosive Volcanism*; Inception, Evolution, and Hazards, report of the National Academy of Sciences, Geophysics Study Committee, Chapter 11 ed. F. M. Boyd, 143-157, 1984

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